Flexible Airborne Architecture

NASA ICNS Conference

1-3 May 2006, Baltomore

Jacky Pouzet

Eurocontrol Communication and Surveillance Business Unit

Communication Domain Manager

Phil Platt

QinetiQ ATM Communications Programme Manager

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Initial Aircraft Architecture Study

Objective:

Review the potential evolution in aircraft architectures to ease accommodation of future communication systems

- Identify changes taking place on large/medium size aircraft to ensure flexibility for aircraft manufacturers and aircraft operators
- Review enabling technologies that will assist in achieving a flexible aircraft architecture
- Describe a vision of the likely avionics architecture explaining how it integrates with the wider CNS infrastructure
- Recommend areas for further work

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Background

- Current aircraft communications systems are federated systems and aircraft
  - Avionics manufacturer driven
  - not designed to accommodate significant changes in communications architecture
- New developments in communications and avionics technologies may also reduce the costs of the communications upgrade
  - implemented in such a way as to provide flexibility
  - allow for further growth and changes in the future

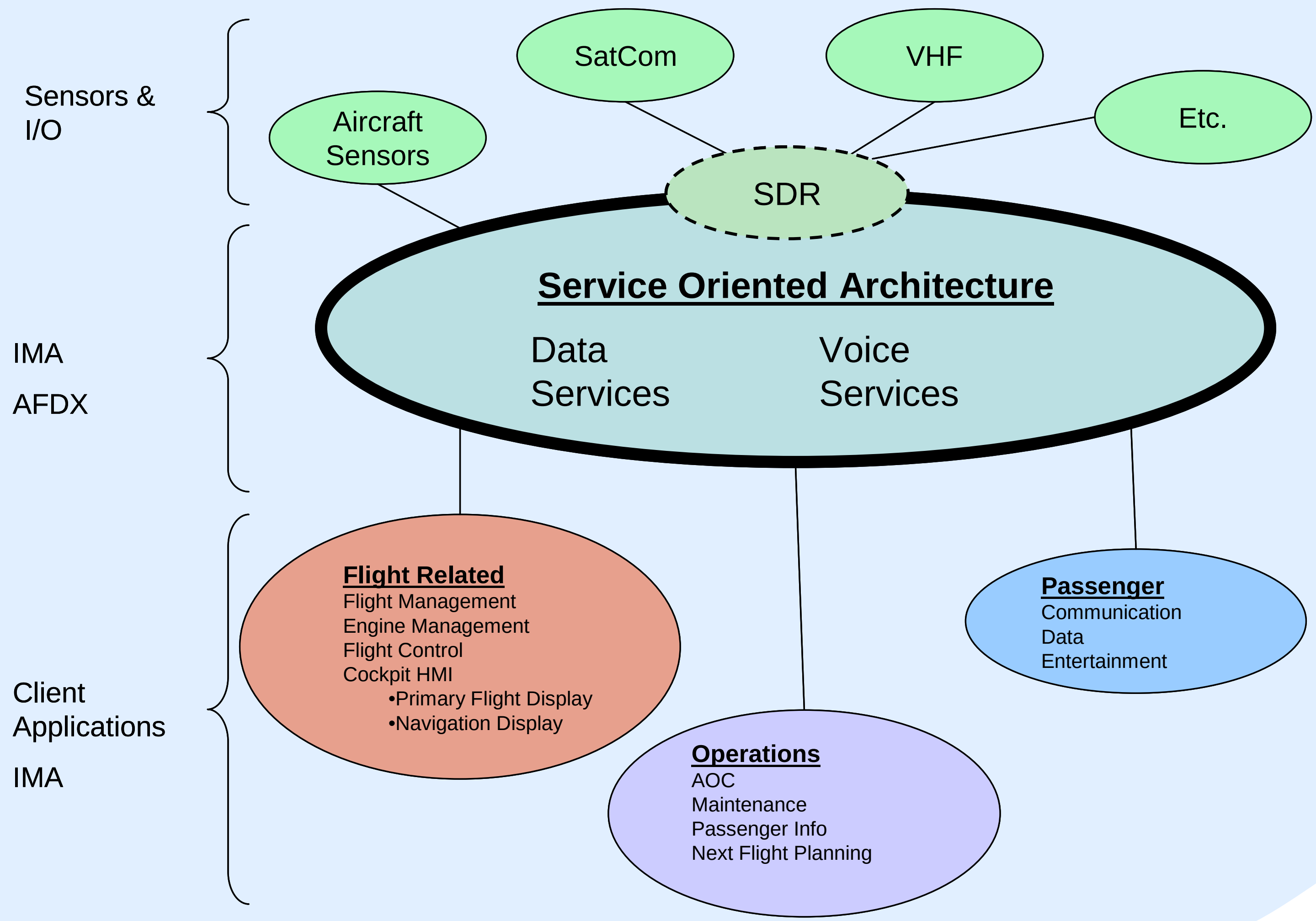
Current avionics

- Many Line Replaceable Units (LRU)
  - Communication systems – multiple VHF radios, HF, satellite, etc
  - Similarly for navigation and surveillance
- Multimode units will reduce unit count
  - Multimode navigation system already
  - Multimode communications systems are expected
- Integration of communication, navigation and surveillance data only takes place in the cockpit HMI and is performed by the pilot at the moment
  - New architectures will enable closer information integration

New aircraft architectures

- Boeing and Airbus have adopted new network-based approach to interconnection on their new aircraft – B787 and A380
  - Enabled through Integrated Modular Avionics (IMA)
- Flexible Application Environment
  - Data is shared more widely with a range of applications
  - Sensors provide data for use by a wide range of applications
- Service-oriented architecture (SOA)
  - Enables integration with current systems in a phased approach without any major architectural changes

Future Avionics Architecture



Layered approach

- Separates specific hardware from applications
  - hardware has an interface to an intermediate layer which then interfaces to the application software
- Avionics Full-Duplexed Ethernet: AFDX
  - Enables interconnection of system throughout the aircraft
  - Based on Ethernet with QoS provisions via ATM to ensure
    - Bandwidth guarantee – allocation of network bandwidth.
    - Real-time control – control of message transfer latency.
    - Service guarantee – monitoring of network loading.

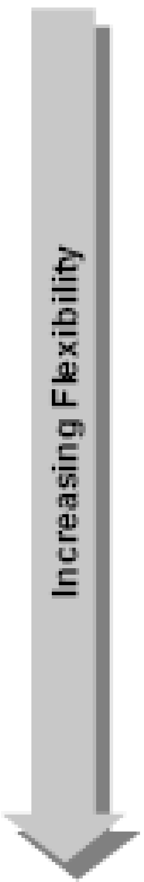
Principle of the Three Layer Stack

Application Layer	Aircraft: **Dependent** Hardware: Independent
Interface	
Intermediate Layer	Aircraft: **Independent** Hardware: Independent
Interface	
Hardware Layer	Aircraft: **Independent** Hardware: Dependent

Software Defined Radio

- SDRs have been made possible by the digital signal processing techniques
- Common hardware to support a range of waveform applications including some or all of the following functions
  - Signal transmission and reception
  - Modulation, error correction coding, protocols etc
  - Communications security (i.e. encryption)
  - Networking functions including routing isolation gateways (e.g. if performing cross-banding or as a rebroadcast station)
  - Application layer gateways (ALGs)

Towards true SDRs



- Conventional Receiver:
  - Traditional all analogue receiver (RF to baseband)
  - Commonly a super heterodyne architecture
- Digital Receiver:
  - Traditional analogue receiver RF front end
  - Baseband or final IF narrow-band digitisation
  - Digital signal processing (DSP) for filtering, demodulation etc
  - Digital control of analogue sections
- Software Defined Radio:
  - Digital receiver, rapidly re-programmable to support different waveforms
  - Waveform processing undertaken digitally, mainly in programmable devices
- True Software Radio:
  - Wide-band digitisation 'close to the antenna'
  - Channel selection, down-conversion, baseband processing done digitally
  - Highly re-configurable 'on the fly' (using software, FPGAs, ASICs)
  - Multi-mode, multi-channel, multi-band

Benefits of SDRs

- SDRs can support the following functions
  - Multi-band
  - Multi-mode
  - Updates to capability
  - Reduced overall size, weight and power for an aircraft
    - A number of radios in one unit
    - US DoD JTRS is a good example

Obstacles to implementing SDRs

- Antenna design
  - Difficult to have cover a wide range of frequencies with one design
- RF linearisation and digitisation
  - Application of digital techniques difficult the nearer you get to the antenna
- Co-site interference is still an issue
- Waveform portability and description languages
- Security
- Certification
- Cost

Antenna Developments

- Antenna aperture sharing techniques
  - Can be common antenna and maybe common RF chain or
  - two or more antennas sharing the same aperture
- Potential groupings for example apertures could be
  - Navigation aids, VHF/UHF communications
  - TCAS, GPS, Navigation aids, UHF communications,
  - Radar, Radar altimeter, Ku/Ka satcomm
- However this requires careful study

Conclusions (1/2)

- Future avionics architecture will see a realisation of evolving technologies to provide the functionality required of a flexible and expandable system
- Rationalisation of antennas to reduce the number and to provide more capability for each aperture in the aircraft's surface
- Aircraft could have a number of software defined radios
  - flexibility to adapt to changes in frequency, modulation and encoding in order to provide access to the developing communication capability
  - SDRs will provide their data as information services, via a robust and extendable network infrastructure, to support cockpit avionics, operational avionics and cabin information services

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Conclusions (2/2)

- A high degree of integration of cockpit avionics will take place operating on a modular and extendable computing capability to provide flexibility, redundancy and support for improvement
- This vision needs to to be confirmed through a roadmap
  - discussed with aircraft manufacturers to align with their planning for new aircraft
  - Monitor the progress of the enabling flexible architecture such as antenna technologies, software defined radios, certification of complex software systems